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EFFECT OF SHADE ON GERMINATION AND GROWTH OF SALMONBERRY

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INTRODUCTION

Salmonberry *(Rubus spectabilis* Pursh.), which forms a major component of shrubby vegetation in coastal areas, occurs mainly west of the Cascade Range in Oregon and Washington, south to California, and north to Alaska. Its preferred habitat is along streams and on benches and moist slopes. Salmonberry is especially common under red alder *(Alnus rubra)* and frequently is found under mature to overmature conifer stands. Following timber harvest, it often develops into dense thickets and delays or prevents forest regeneration.

Literature on salmonberry includes botanical descriptions *(1, 7, 13)*,[1/] reports on habitat preferences and associated species in local floras and plant community classifications *(2, 5, 18)*,[2/] [3/] silviculture articles about its competition with conifer seedlings *(4, 6, 11, 12, 17)*, and reports on control by herbicides *(9, 10)*. Isaac *(8)* observed the vegetative cover on 15 logged areas in the Douglas-fir *(Pseudotsuga menziesii)* region of western Oregon and Washington and found that salmonberry cover increased from 1.1 percent soon after logging and slash burning to 2.7 percent 8 years later. Frequency on his study plots increased from 14 to 43 percent in the first 5 years.

This report describes salmonberry development under various shade levels in the forest and in a forest opening. Data were collected during silvicultural studies of conifer seedling establishment on the same plots.[4/]

1/ Italic numbers in parentheses refer to Literature Cited, p. 9.

2/ Sharpe, Grant William. A taxonomical-ecological study of the vegetation by habitats in eight forest types of the Olympic rain forest, Olympic National Park, Washington. 1956. (Unpublished doctoral thesis on file at Univ. Wash., Seattle.)

3/ Bailey, Arthur Wesley. Characterization of selected plant communities within the Tillamook burn in northwestern Oregon. 1963. (Unpublished master's thesis on file at Oreg. State Univ., Corvallis.)

4/ Ruth, Robert Harvey. Differential effect of solar radiation on seedling establishment under a forest stand. 1967. (Unpublished doctoral thesis on file at Oreg. State Univ., Corvallis.)

SALMONBERRY CROWN COVER

Observations of salmonberry were begun in the spring of 1956 on a 12-acre tract on the central Oregon coast 5.5 miles from the Pacific Ocean. The 113-year-old timber overstory of Sitka spruce *(Picea sitchensis)* western hemlock *(Tsuga heterophylla)* and Douglas-fir had been thinned 9 years earlier to about 80-percent canopy closure. A second partial cutting, the beginning of a shelterwood harvest cut made in the summer of 1956, reduced canopy closure to a fairly uniform 60 percent. Salmonberry crown cover under the timber stand was estimated on a grid of 124 1-milacre plots, with cover interpreted as the vertical projection of a polygon drawn around the undisturbed canopy. Only the dominant canopy not overtopped by other shrubs or herbaceous plants was included in the estimate. Observations were made prior to the second partial cutting and periodically during the next 7 years.

Salmonberry cover increased following reduction of the forest overstory. It was 3.1 percent in the spring of 1956 just prior to the second partial cutting. The cutting operation reduced it to 1.1 percent, largely through mechanical damage. There followed a consistent expansion of salmonberry crowns, with cover reaching 14.6 percent 7 years later (fig. 1).

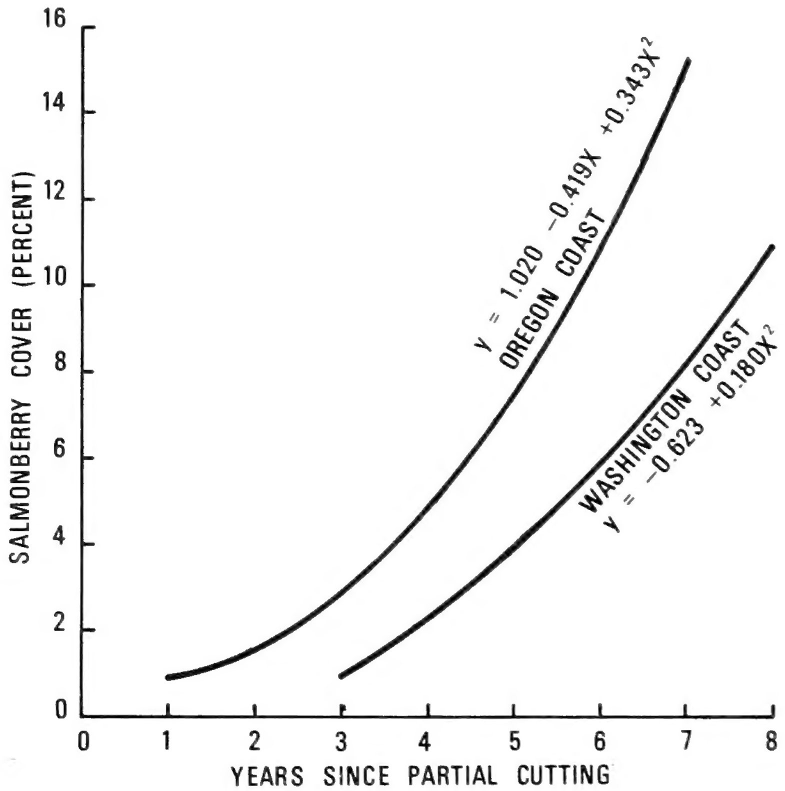

Figure 1.--Regressions of salmonberry crown cover on years since reduction of the forest overstory, by location.

A second study was begun on the Washington coast in the summer of 1960 on a 67-acre tract about 10 miles inland. A 58-year-old timber stand of almost pure western hemlock was divided into 12 treatment areas, and each stand was partially cut to leave a different basal area per acre. The cuttings, which were part of a shelterwood harvesting schedule, were made in two stages, the first in 1960-61 and the second in 1964-65. Considerable blowdown occurred in October 1962, and this was salvaged during the 1964-65 cutting. Basal areas remaining after the second cut ranged from 20 to 159 square feet per acre. Salmonberry crown cover was measured on 24 to 26 1-milacre plots established systematically on a central acre within each treatment area. Crown cover was estimated as before, but this time crowns of all salmonberry plants were included, even if they were overtopped by other vegetation. Periodic measurements were made through 1968.

Salmonberry cover again increased after partial cutting (fig. 1).

SALMONBERRY GERMINATION AND ESTABLISHMENT

Method

A third study was established in 1963 under a 120-year-old Sitka spruce, western hemlock, and Douglas-fir stand on the central Oregon coast. The timber had been thinned 1 to 2 years previously along four lines of plots to provide gradual decrease in overstory density and increase in solar radiation reaching the forest floor from plot to plot along each line. A total of 89 scarified 1-milacre plots were established at approximately 27-meter intervals along the lines. Plots that fell on slopes over 30 percent, in creek bottoms, or on roads were rejected. Scarification was done by tractor and bulldozer in September 1963. All ground vegetation was removed, but as much topsoil as possible was left. The northwest quadrant of each milacre was leveled with hand tools March 11-12, 1964, and a 30-centimeter-square wooden frame installed with about 1 centimeter of the edge protruding above the soil level. A supplemental group of 10 plots was installed in a nearby clearcut area. Both installations were completed in March 1964. Salmonberry seedlings that germinated inside subplot frames were counted periodically until September 22, 1965.

Additional subplots were established under the timber stand on the northeast quadrant of 43 of the milacre plots on May 14, 1964. The procedure was similar, except that bronze window screen, rather than a wooden frame, was used around the subplot, and hardware cloth was placed over the top until July 16 to keep out rodents. Supplemental plots again were established in the clearcut. Seedlings germinating before May 14 were destroyed during subplot establishment. During April 15-21, 1965, 89 additional subplots were installed in the southeast quadrant of the milacre plots and 10 more in the clearcut, using screen around the plot boundary and hardware cloth covers. The covers were removed May 19 and seedlings counted periodically until fall.

None of the plots was seeded with salmonberry seed. Slope was a fairly uniform 10 percent to the north. Variation due to competing understory vegetation was reduced by the scarification procedure. Two plots were destroyed by windthrown trees during the study.

Radiation reaching the milacre plots was measured chemically using a solution of anthracene, $C_6H_4CH{:}C_6H_4{:}CH$, in benzene, C_6H_6 *(16)*. Calibration was with a Moll Gorczynski solarimeter. Anthracene vials were exposed August 5, 1965, which was a clear day; August 26, 1965, which was partly cloudy; and September 8-10, 1965, during cloudy weather. Additional vials were exposed simultaneously in the nearby clearcut area to permit expressing radiation under the timber as a percent of that in the open. Numbers of salmonberry seedlings on the plots were converted to a per-acre basis and related to radiation through regression analysis.

Earlier measurements of soil moisture in the study area in the 0- to 15- and 15- to 30-centimeter depth classes had shown that soil moisture tension did not get above 15 atmospheres, indicating that soil moisture was continuously available to plants. By 1965, however, general observations of surface drying between summer showers indicated that moisture might indeed have been limiting near the soil surface where initial radicle penetration was taking place. Precipitation totaling 9 millimeters fell August 19, 1965, and this was followed by a slow drying out of surface soil. Samples were collected on September 9, 1965, at four depths along one line of milacre plots and in the clearcut. Plot size was 25 centimeters square, and sampling depths were 0- to 2-centimeter by 0.5-centimeter increments. Soil moisture percent was related to radiation by regression analysis with covariance analysis used to test for significant differences among depth classes. A composite sample was analyzed in the laboratory to determine moisture percent at 15 atmospheres soil moisture tension.

Number of Seedlings

Large numbers of salmonberry seedlings became established on the scarified seedspots (table 1). Almost one-half million seedlings per acre were observed on the wood-framed seedspots July 16, 1964. Only one of the 87 seedspots examined failed to produce at least one salmonberry plant by this date. Additional seedlings germinated in the spring of 1965, reached a maximum about the first of May, slowly declined in numbers during the summer, then increased again on both the wood-framed and screened seedspots after the beginning of the fall rains in September. Second season germination was only about 6 percent of that occurring the first season.

On the screened seedspots established April 15-21, 1965, germination did not begin until after May 24 and maximum number of seedlings per acre was only 14,680; there was no increase in seedling count in September (table 2).

Table 1.--*Salmonberry seedlings on 1964 scarified seedspots by examination date, type of plot, and cover class*

Examination date	Wood-framed seedspots		Screened seedspots	
	Under timber	In open	Under timber	In open
	- - - - - - - - - - *Number per acre*	- - - - - - - - - -		
1964 germination:				
June 25-26, 1964	493,760	146,200	368,430	2,080
July 16, 1964	495,540	111,800	240,670	590
Apr. 9-12, 1965	267,300	--	42,610	0
1965 germination:				
Apr. 9-12, 1965	2,700	--	8,910	--
Apr. 28-May 3, 1965	16,200	0	27,710	0
May 19-24, 1965	8,900	0	14,860	0
June 8-9, 1965	4,450	0	5,940	0
June 30, 1965	4,450	0	2,970	0
Aug. 11-12, 1965	3,560	--	2,970	--
Sept. 22, 1965	10,680	--	14,860	--

Table 2.--*Salmonberry seedlings on scarified seedspots established in 1965, by examination date and cover class*

Examination date	Under timber	In open
	- - - - - *Number per acre*	- - - - -
May 19-24, 1965	0	0
June 8-9, 1965	2,940	0
Aug. 11-12, 1965	14,680	--
Sept. 22, 1965	5,870	--

Seedspots in the clearcut area which were exposed to full solar radiation were in a much less desirable environment for salmonberry establishment than those under the forest canopy (tables 1 and 2). The highest number of seedlings was on the wood-framed seedspots June 25-26, 1964. There was a reduction of almost 25 percent by July 16, with no seedlings surviving to the following April and no second-season germination. No seedlings became established on the exposed seedspots established in 1965.

Shade Effects

On the scarified plots under the forest canopy, solar radiation accounted for only a small part of the variation in seedling establishment. On the screened seedspots, numbers of seedlings decreased significantly with increasing radiation at both 1964 examinations (fig. 2). However, radiation accounted for only 13 to 16 percent of the variation, and the relationship was no longer significant when measured the following April after winter mortality.

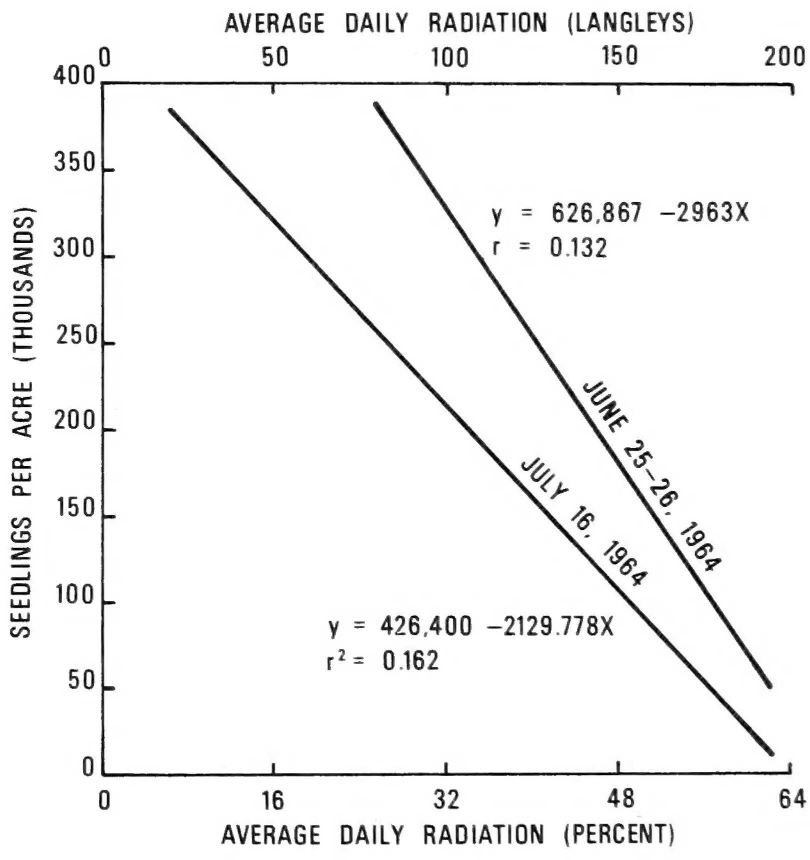

Figure 2.--Regressions of salmonberry seedlings per acre on radiation by examination date, screened seedspots.

On the wood-framed seedspots, the sample was larger, but no significant relationship between numbers of seedlings and radiation was found for either 1964 observation. When examined the following April, an increase in number of seedlings with increasing solar radiation was significant at the 5-percent level. Apparently overwinter mortality had been greater at the lower radiation levels. New seedlings becoming established the second season followed the pattern on the screened seedspots and showed a slight, but significant, decrease with increasing radiation (fig. 3). In these analyses only 6 to 8 percent of the variation in numbers of seedlings was related to radiation.

Soil moisture measurements by half-centimeter depth classes on September 9, 1965, showed a highly significant difference in moisture percent among the depth classes, and in all classes a highly significant decrease in soil moisture with increasing radiation. Soil moisture tension in the composite sample reached 15 atmospheres at 41.4 percent moisture. Taking this as an estimate of the wilting point, the soil moisture curve for 0- to 0.5-centimeter depth passed below this level where radiation averaged 100 Langleys per day, or 32 percent of radiation in the open. The 1.5- to 2.0-centimeter curve did not do so until radiation averaged about 195 Langleys per day, or about 60 percent of radiation in the open.

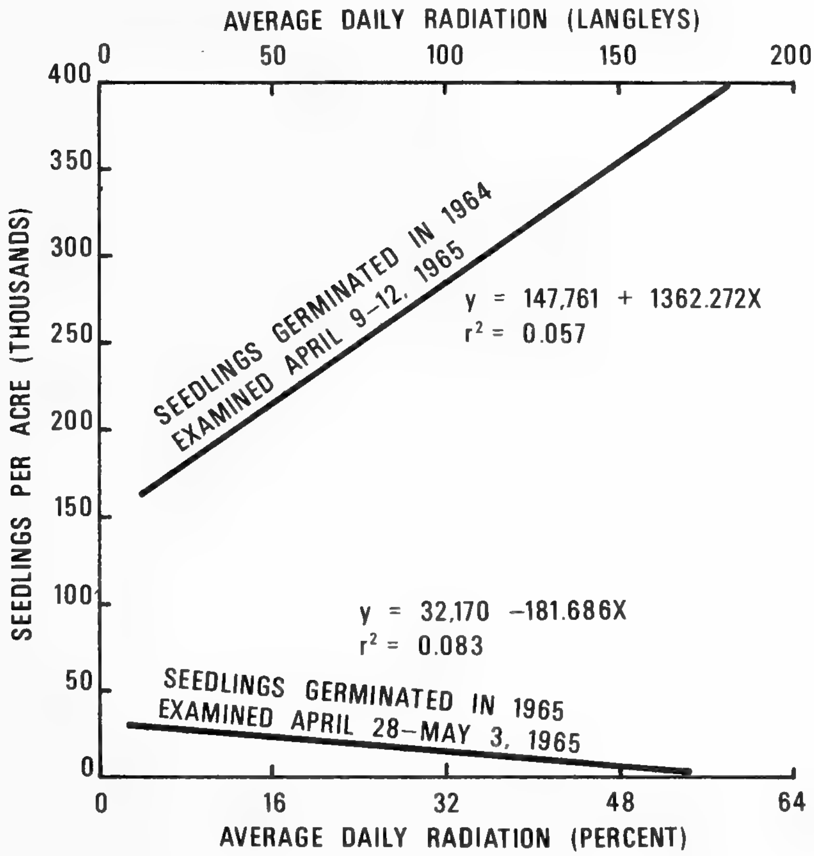

Figure 3.--Regression of salmonberry seedlings per acre on radiation by examination date, wood-framed seedspots.

DISCUSSION

It seems a reasonable hypothesis that large numbers of viable salmonberry seeds are present in the forest topsoil under coastal forest stands. The seed in our study did not come from a new crop, because none ripened between scarification in September and the prolific salmonberry germination the following spring. Carrying seed from plot to plot on the bulldozer or on our boots or hand tools was a possibility, but the distribution of new plants seemed too uniform for that. Also, an occasional strip of two or three plots had no seed-bearing salmonberry plants nearby, so any soil containing salmonberry seed would need to have been carried a considerable distance. Most seedlings were first observed in the cotyledon stage, attesting to their origin from seed. Depth of scarification ranged mostly from 5 to 15 centimeters into the mineral soil, indicating viable seed may have been present throughout this range. Frequent burrowing by moles (*Scapanus* spp.), which are common insectivores in the area, could account for this distribution. Research with other species has shown that seed can remain viable in the soil for long periods of time *(3, 14, 15, 19)*. The importance of salmonberry to coastal forest ecology and silvicultural practice warrants further examination of seed storage in the forest topsoil.

Salmonberry demonstrated a tolerance of heavy shade. In the coastal Oregon study, one seedling survived its first season on a scarified plot which received an average of only 7.2 Langleys per day, or 2.3 percent of radiation in the open.

Solar radiation received under the forest canopy ranged up to almost 70 percent of radiation in the open, and as far as first-year seedling establishment was concerned, the shade level had little effect. The significant relationships that were found showed decreasing numbers of seedlings with increasing radiation (figs. 2 and 3). But the coefficients of determination were low, indicating that little of the variation was explained by radiation alone. That some shade is important, however, was demonstrated by better survival under the forest canopy as compared with the clearcut (table 1). In the open, and to a lesser extent with increasing shade from the forest canopy, the soil surface dried out during short periods of clear weather. Perhaps penetration of the radicle into the soil could not keep pace with receding soil moisture so that drought rather than too much radiation limited seedling establishment. On the other hand, established salmonberry plants with their roots in permanently moist soil seem to do best in full light. The densest salmonberry thickets are found in forest openings rather than under timber stands.

The increase in salmonberry crown cover following reduction of the forest overstory was expected. Most of the increase was in crowns of existing plants, but some new plants were involved, especially in the Washington study. Cover averaged more under the Oregon forest stand, probably because the stand was older and had been lightly thinned 9 years before observations began. The timber stand in Washington was more dense, with salmonberry in the understory covering less than 0.1 percent of the soil surface at the start of the study. Here

it took salmonberry cover about 3 years to reach 1 percent; then the rate of increase was similar to the Oregon area (fig. 1).

Repeated thinnings surely will lead to increased cover, so salmonberry seems destined to remain an important part of coastal forest communities. To the extent it competes with tree seedlings, its control will need to be an essential part of silvicultural practice.

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